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Electronic Business

FOR MANAGEMENT IN ELECTRONICS, COMPUTER & SYSTEMS COMPANIES — WORLDWIDE

APRIL 16, 1990

HEADING FOR UNITY

Is this the year Unisys finally gets it together?

Top semiconductor companies – worldwide
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Japanese continue aggressive spending
PAGE 76

James Unruh, Unisys' president and CEO

Electronic Business

FOR MANAGEMENT IN ELECTRONICS, COMPUTER AND SYSTEMS COMPANIES — WORLDWIDE

VOL. 16, NO. 7 APRIL 16, 1990

Cover photograph: Eugene Mopsik

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36 Is this the year Unisys' products finally connect?

Four years after the Sperry-Burroughs merger, a hodge-podge of products still plagues the company that thought being bigger meant growing faster. Connecting Unisys' disparate hardware lines into a coherent system is the job of James Unruh, who has taken over the chief executive mantle from chairman W. Michael Blumenthal. Despite the hurdles he faces, Unruh says 1990 is the year Unisys gets it all together.

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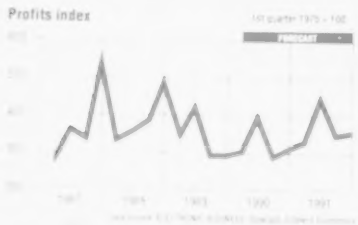

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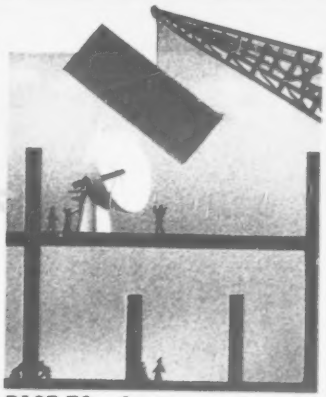

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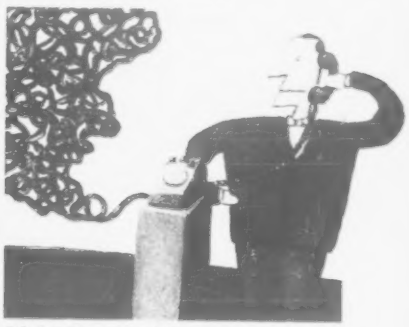

PAGE 70 Political compromise may tangle Europe telecom deregulation

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70 **Political compromise tangles Europe telecom deregulation**

The European Community approved two directives late last year that paved the way for free competition in many telecommunications services by 1993. While the move was hailed as a major step in liberalizing Europe's largely monopolistic telecom industry, the fine print is being interpreted differently.

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Japan's top 10 electronics corporations are investing nearly as much in research and development and capital equipment as do the top 100 U.S. electronics companies combined. With this huge investment the Japanese are achieving 10% to 30% improvements in value added per worker in their primary businesses in Japan.

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ASICs are hot items these days, but there are two sides to the picture. Virtually all of the growth in ASICs is limited to digital devices, while analog growth is stalling. There are markets to be had by analog ASICs vendors, but imposing technological obstacles must be cleared first.

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A new outlook

A couple of issues ago senior editor Rick Whiting wrote an instructive piece on the secrets of managing a successful product transition (Feb. 19 issue, page 34).

I bring his article up because ELECTRONIC BUSINESS has also been in the throes of managing a product transition — our product, of course, being the magazine. In this case, we made what we believe will be some successful product changes in the front portion of our publication.

Rick's story contained a listing of 12 ingredients of a successful transition. And while most of the items on the list can't possibly apply to a magazine, one ingredient certainly hits home: "Begin planning the transition during the product design."

That is essentially what we did in revamping the front several pages of ELECTRONIC BUSINESS. During our product design, we began planning in earnest for the transition, and here we are, the April 16 issue.

Here's what we did: spiked the one- and two-page "Business Trends" section format in favor of shorter, more topical articles under the "Update/Business Trends" heading; redesigned the "Upstarts" column and renamed it "Update/Companies to Watch," and added two features, "Update/Economic Trends" and "Update/Commentary."

Here's a sampling of what's in store. In "Update/Business Trends," we examine the impact of IBM's flexing its muscles in the workstation arena: look at the wrangling between the Baby Bells and cable TV operators, and zero in on "Wrestlemania" laptop wars among Compaq, Toshiba and Zenith. And that's just for starters. The new format allows us to offer timely perspective about events more quickly — in advance of stories that typically evolve into longer features later.

Update

IBM flexes its muscles in the fast-growing workstation market

Telcos reach out for cable TV rights

"Update/Business Trends"

The "Update/Companies to Watch" page will continue to focus on emerging technology companies and be written by contributing editor Sarah Glazer. "Update/Economic Trends" is the domain of senior editor Bruce Rayner, who'll pinpoint and analyze big picture economic trends as they affect electronics.

Probably best of all is the return of the penmanship of our former editorial director Alberto Socolovsky, who'll contribute occasional pieces to "Update/Commentary." In his inaugural column Alberto uses the president's State of the Union address as a backdrop in examining what electronics companies need to do to be better manufacturers.

MARVIN GREENE, section editor

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BPA ABP

market in battery-powered portable PCs. But Compaq rose quickly that year; its slick SLT-series laptops captured almost 40% of all laptop sales by U.S. computer dealers by year-end.

Compaq's success continued in 1989 with the LTE, the first notebook-sized PC with a hard drive and standard floppy drive. Observers expect the LTE to vault Compaq onto the leader board for 1990. "They are the hot contender," says International Data Group's Bruce Stephen, who predicts a three-way bottleneck between Compaq, Toshiba and Zenith this year.

Toshiba's venture into hostile territory is evidence it has heard the wake-up call. Computer division vice president and general manager Bill Johnson said it straight that night: "The LTE was a significant breakthrough, and I congratulate Compaq. But that was 1989, and this is 1990. Starting tonight, you can have it all."

To prove it, the company has launched the Toshiba Challenge, a side-by-side comparison of the new T1200XE and Compaq's LTE. Initial market research shows an 80% winning percentage for the newcomer, the company claims, mostly on the power of a larger screen, a more comfortable keyboard and a $500-less price tag.

Observers say that Toshiba's turf-war tactics are a major departure for the company. "Up until now, [Toshiba's] products have driven the company," says IDG's Stephen. "Now I think they want to control their destiny and be more proactive. The underlying message is that they will get more aggressive."

Toshiba may be setting an industry trend as well — the "Wrestlemania approach to marketing," as Stephen defines it. With more rivals —including IBM — expected to throw notebook-sized models into the ring, "It's time to wake up and differentiate yourself from the crowd," Lempesis says.

What about Zenith Data Systems, the ex-champ? As recently as last year, it was the market leader with a healthy 30.3% share, according to Dataquest. Sold in October to France's Groupe Bull, the Zenith name now stands to lose its firm hold on U.S. government contracts and is widely considered an also-ran. The company has even had trouble collecting on its purchase price; having seen the fourth quarter results, Bull reduced its $496 million offer by $103 million.

PETER BURROWS

ASIA/PACIFIC

Japan spends more, boosts worker output

IT IS NO SECRET that Japanese electronics companies, bolstered by a low cost of capital, invest more aggressively in capital equipment than do their U.S. counterparts. This lavish investment makes Watanabe-san a more productive worker. Here are a few examples of investment per worker at selected major Japanese electronics plants:

PAULA DOE

Company Plant (product)	Equipment investment per worker	Total plant and equipment assets per worker
NEC		
Central research lab	$33,400	$98,100
Sagamihara (telecom equipment, electronic devices)	$28,200	$63,500
Tamagawa (telecom equipment, electronic devices)	$24,900	$54,800
Fuchu (computers, telecom equipment)	$20,900	$61,900
Fujitsu		
Mie (IC development and pilot production)	$214,500	$338,000
Aizu (semiconductors)	$33,000	$65,200
Iwate (semiconductors)	$31,800	$69,700
Oyama (telecom equipment)	$14,200	$52,100
Hitachi		
Odawara (computer input/output devices)	$94,400	$114,300
Asahi (small computers)	$37,800	$61,100
Musashi (LSICs, ICs)	$34,800	$48,600
Takasaki (bipolar ICs)	$25,900	$53,000

Figures are for fiscal 1988, ending March 1989 for most companies

Source: Company reports

EUROPE

Can Brits break Japan's hold on flat screens?

THE BRITISH WANT a flat playing field for flat screen displays. To create one, the government is spearheading a European research initiative designed to break the Japanese stranglehold on LCDs.

Guided by IBM in England, the British government is seeking support across Europe for a major pan-European LCD research effort. The proposed joint government and industry project grows from concerns Japan one day will choke off Europe from its supply of LCDs, which are increasingly important to computer-system packages.

"The display will be the most visible part of the system, and may well drive the system," warns one British systems manufacturer. "If you don't manufacture your own displays, you won't get a state-of-the art display into your products."

The British government late last year sponsored a study mission to Japan with delegates from IBM's department for liquid crystal technology, Thorn EMI, British LCD maker General Electric Co. and academia. Also attending were Pilkington Bros. Ltd., a manufacturer of flat glass for the screens, and the chemical firm BDH Ltd., which supplies liquid crystal to Japan's LCD makers.

Britain's trade ministry now is canvassing for funding support from other governments to guard against what it estimates as Japan's $1 billion

COMPUTERS

Pace of computer growth to slow through decade

IF YOU THOUGHT 1989 was a slow year for computers, then you won't like the prognosis for the rest of the decade. Last year saw the third-slowest growth rate for revenue in computer and business equipment since 1970, but it still was above the projected average annual growth rate for the 1990s, says the Computer and Business Equipment Manufacturers Association (CBEMA).

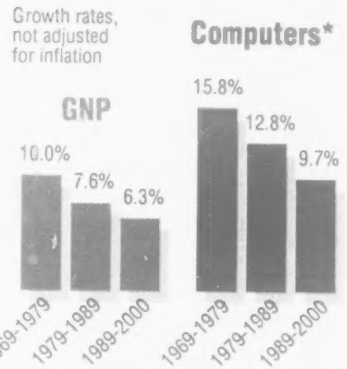
Worldwide revenue growth for U.S. computer and business equipment dipped to 10.3% in 1989, down from 14.5% for 1988, according to CBEMA. The international trade organization is forecasting a 9.7% average annual growth rate for the rest of the century.

The forecast points to a long-term trend toward maturation of the computer industry. The 1980s saw a 20% drop in the industry's growth compared with the 1970s, and the 1990s will see a 27% decline compared with the 1980s. The size of the market is helping to slow the growth, as is foreign competition and market saturation.

Still, 9.7% overall growth is nothing to sneeze at. "We are optimistic," says Helga Sayadian, a CBEMA forecaster. She believes the demand for automation equipment and productivity-enhancing computers will keep the fires burning under the domestic computer industry.

BRUCE C.P. RAYNER

A slow trek to 2000



* Includes computers and related, software and services, business equipment and business forms

Source: Computer and Business Equipment Manufacturers Association

IMPORTS

Japan to relax import regs, boost tax credits

IT SEEMS Washington's strong-arm trade tactics with Japan are having some effect. Starting this month and lasting for three years, Japan will introduce a new import incentive program for Japanese buyers of foreign goods, according to Japan's Ministry of International Trade and Industry. MITI estimates the new plan will increase Japan's imports by $3 billion.

The import program gives Japanese manufacturers a 5% tax credit on imports of qualified capital goods if those imports are at least 10% above the largest value of imports in recent years. Included in the qualified category of imports are semiconductors and computers. The import program also gives Japanese distributors and wholesalers tax incentives to develop markets for imports.

In addition, Japan will eliminate or reduce tariffs on 1,008 products with an estimated import value in 1988 of $13 billion. By the time the program is fully implemented, 56% of manufacturers' imports will enter Japan duty-free. MITI also plans to set up 49 in-country import offices to encourage imports.

Some think this is only smoke and mirrors to keep U.S. Trade Representative Carla Hills and her Super 301 team pacified. "In general, I'm skeptical," says Susan Lynner, vice president of government research with Prudential Bache-Securities Inc. in Washington, D.C.

First of all, Japan has made noises about opening its borders before with little effect. Even more frustrating, says Lynner, is the possibility this incentive will be used by Japanese companies to boost their purchases of imports from foreign-based Japanese manufacturers.

How much of that $3 billion will come from electronics imports is hard to gauge. Capital goods are expected to account for about $1.5 billion, of which a portion will be high-technology capital goods. According to MITI, the U.S. share of all Japanese imports currently is about 22%, but the share of the items covered under these tax measures will be closer to 40%. — B.R.

EXPORTS

Government, industry and the supercomputer

THE U.S. DEPARTMENT of Commerce could seriously hinder U.S. exports in its attempt to define a supercomputer, critics say. Supercomputers are considered a U.S. technological stronghold, but some experts insist that if the new definition goes into effect that strength could slip.

Any exporter of a computer with a speed of greater than 100 million floating-point operations per second (megaflops) has to obtain an export license, according to the new definition from Commerce.

"It would be economically devastating if they actually followed through with the 100 megaflops definition," says Debra Goldfarb, International Data Corp analyst.

U.S. manufacturers say they will become bogged down in a morass of export-licensing bureaucracy and that foreign competitors will easily pick up the slack. European machines do not have to comply with any U.S. export regulations.

IBM, DEC and others have joined the American Electronics Association in proposing an alternative export criteria based on a system of indexing. The AEA says the peak performance of the two most powerful commercially available machines in the world — currently at 3000 megaflops — should be averaged and systems with more than 25% of this average speed would be subject to the restrictions if exported to Western allies. For all other countries, exports of supercomputers would be limited to machines with 10% of the megaflops average.

GIUSEPPE LABIANCA

Mr. President: Manufacturing is management's job

In his State of the Union address, President Bush challenged the nation to make the "Made in the USA" label "recognized as a symbol of quality and progress."

In the president's view, the country must prop up three pillars to support the achievement of such a worthwhile goal: capital, literacy, and personal productivity. He pledged to encourage the investment in "the physical capital needed to produce and deliver quality goods and services," and to ensure that, by the end of the century, "every American adult must be literate." President Bush implied that the third pillar is already in place, because he called the American worker "the most productive worker in the world."

He didn't mention the most important factor in achieving his goal: management's commitment to quality. He knows many of the captains of U.S. industry, and he has come to office with more knowledge of the electronics and computer industry than any other president, so perhaps he plans to inspire management at face-to-face meetings.

Affordable capital, high literacy and dedicated workers all help and are the necessary ingredients to a successful manufacturing industry. But they are not sufficient. Only the guidance and example of a committed management team can provide the synergy to make a productive labor force and modern capital equipment work harmoniously to create high quality, functional products.

To underscore this point, look on this page at the high ratio in sales per employee (and, correspondingly, high net income per employee) at companies such as Apple and Compaq. These companies don't make everything they sell — no successful manufacturer does. They don't try to compete with their suppliers of keyboards or power supplies, but instead they concentrate on making efficiently the major parts that lend distinction to their computers.

Even IBM, once a paradigm of a vertically integrated manufacturer, understood 10 years ago that it was more economical to subcontract the manufacture of its first PCs to SCI Systems of Huntsville, Ala., than to make them. IBM still follows that model. It recently enlisted Arix Corp.'s powerful minicomputers in its bid to the U.S. Treasury for a big multiuser system.

To keep its own manufacturing operations competitive, IBM planners periodically evaluate making versus buying for many of its products, from memory chips to mainframes. One of the scenarios they have been considering lately is to stop making hardware altogether. The hoped-for result is to keep IBM from following the example of erstwhile competitor Honeywell Inc., which quit making mainframes four years ago. Bull HN Information Systems Inc. picked up Honeywell's mainframe business with Japanese machines made by NEC.

There is no single solution for our industry's manufacturing problems. Semiconductor manufacturers constantly are squeezed between new competitors for their current products and the investment required to make new ones.

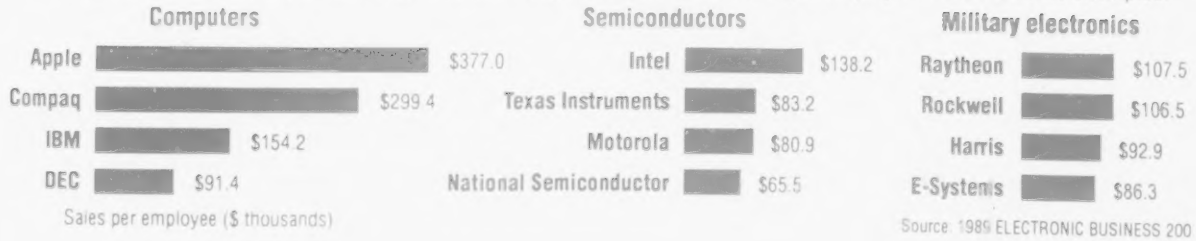
Even if the president's goals can be achieved in this decade, there is still a need for better manufacturing awareness by top management. My occasional column hopes to help in filling that need by bringing manufacturing successes, and perhaps some insight about manufacturing, to the attention of managers of electronics companies. The president may still choose to deliver his message in face-to-face meetings, but ELECTRONIC BUSINESS reaches more managers than he can possibly meet with. □

ALBERTO SOCOLOVSKY

Consulting editor Alberto Socolovsky is the former editorial director of Electronic Business

Manufacturing success stories

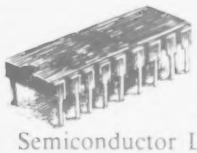
One gauge of a company's manufacturing efficiency is a high ratio of sales per employee. Here are some examples:



Source: 1989 ELECTRONIC BUSINESS 200

Big spenders reap big chip harvests

Samsung and Siemens make huge strides among the world's top 20 semiconductor producers, thanks to massive memory investments in Europe and Asia



When Intel Corp. agreed early this year to team up with Japan's NMB Semiconductor Ltd. to produce and sell NMB's DRAMs, it put into writing what most of the industry had known for years: The world's lineup of chip makers is still being shaken by a combination of new technology, marketing strategy and simple economics.

The agreement was just the latest development in what many observers see as America's inexorable slide from its erstwhile position as the world's top semiconductor supplier.

If more proof is needed, consider the list of 1989's top 20 semiconductor companies, as compiled by market researcher Dataquest Inc. That list is notable not for who's on it — the names are unchanged from the previous year — but for the fact that the U.S. share of world chip sales slipped from 23% in 1988 to 21.7% in '89. In fact, every one of the six U.S. companies on the list posted a market-share decline last year; by contrast, the top five Japanese producers — NEC, Toshiba Corp., Hitachi Ltd., Fujitsu Ltd. and Mitsubishi Corp. — increased their combined share slightly, from 34% to 34.7%.

Not surprisingly, the most successful chip companies last year were the ones that focused on fast-growing products. Examples include such DRAM producers as Toshiba, Germany's Siemens AG and Korea's Samsung Electronics Co. Ltd., now the world's fourth-largest DRAM producer, according to market research company Integrated Circuit Engineering Corp. (ICE).

BY H. GARRETT DeYOUNG

On the Dataquest list, Samsung and Siemens posted the biggest growth rates between 1988 and 1989 — 42% and 32%, respectively. "Both companies can attribute a good portion of that growth to 1-megabit DRAMs," says Patricia Cox, manager of central research at Dataquest's Components Group. "During the past two years, that was the place to be if you wanted to score some big market-share gains."

Indeed, several companies reaped the benefits of their earlier DRAM investments during 1989. The reason, notes ICE: a 37% boost in DRAM sales — $9.2 billion from $6.7 billion in 1988. As a result, DRAMs now account for as much as half of Siemens' semiconductor business, says Wilfried Backes, president of the company's components group in Iselin, N.J., and some 80% of Samsung's North American semiconductor business, according to vice president Keith MacDonald.

In general, companies whose semiconductor sales grew at above the industry average of 9.8% have MOS memories to thank; most were blessed with portfolios rich in DRAMs as well as other MOS memory devices, such as SRAMs and ROMs.

Oki Electric Industries Co. Ltd. grew 19% on the strength of single in-line memory modules containing 256K and 1 megabit DRAMs. Sharp Corp., enjoying strong demand for its SRAMs and ROMs, grew 19%. SGS-Thomson Microelectronics Inc. in Carrollton, Texas, credits its acquisition of Inmos Corp. for 8% of its total growth rate of 20%. "We were expecting [the SRAM] segment to move," explains president Daniel Queyssac, "and the Inmos acquisition gave us some new products."

The acquisition also allowed SGS-Thomson to position itself in the emerging 32-bit microprocessor market via Inmos' Transputer chip, which Queyssac calls the best-selling device of its type in the world.

Chip makers losing market share in 1989 have a different story to tell. Despite their best efforts to move into fast-growth product areas, these companies found themselves wed to mature and maturing commodities such as standard logic, older generation microprocessors and discrete devices. Advanced Micro Devices Inc. tumbled five places on the Dataquest ranking to the No. 18 slot on sales that remained flat at $1.08 billion. National Semiconductor Corp. retained its 11th-ranked position, but its market share shrank by 0.3% and revenue by 2%. Texas Instruments Inc.'s market share, meanwhile, slid by 0.4% to 5%, with sales growing by a mere 2%. "We were overweight in digital logic and underweight in microprocessors," admits TI vice president Walden C. Rhines. "Clearly, our goal is to regain market share."

A hot market cools down

That goal is shared by every U.S. company, of course. Consequently, a variety of strategies are being crafted to beef up existing product lineups, zero in on new high-growth applications.

The top of the heap

Top semiconductor manufacturers— worldwide

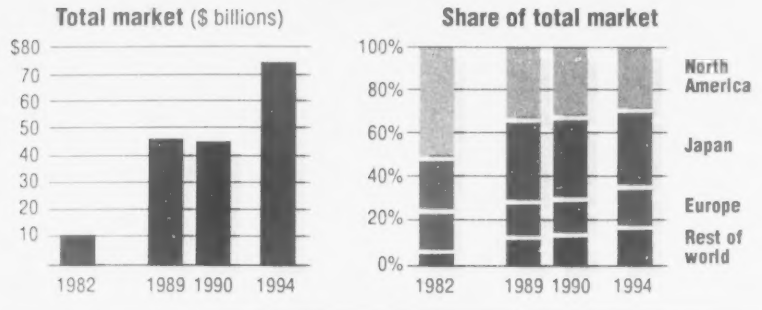
Rank '89	Rank '88	Company	1989 revenue ($ millions)	Change from 1988	1989 market share
1	1	NEC	$4,964	+9%	8.9%
2	2	Toshiba	4,889	+11%	8.8%
3	3	Hitachi	3,930	+12%	7.0%
4	4	Motorola	3,322	+9%	5.9%
5	6	Fujitsu	2,941	+13%	5.3%
6	5	Texas Instruments	2,787	+2%	5.0%
7	8	Mitsubishi	2,629	+14%	4.7%
8	7	Intel	2,440	+4%	4.4%
9	9	Matsushita	1,871	-1%	3.4%
10	10	Philips	1,690	-3%	3.0%
11	11	National Semiconductor	1,618	-2%	2.9%
12	12	SGS-Thomson	1,301	+20%	2.3%
13	18	Samsung	1,284	+42%	2.3%
14	15	Sharp	1,230	+19%	2.2%
15	20	Siemens	1,194	+32%	2.1%
16	14	Sanyo	1,132	+5%	2.0%
17	17	Oki	1,125	+19%	2.0%
18	13	Advanced Micro Devices	1,082	0%	1.9%
19	16	Sony	1,077	+13%	1.9%
20	19	AT&T	873	+2%	1.6%

Source: Dataquest Inc.

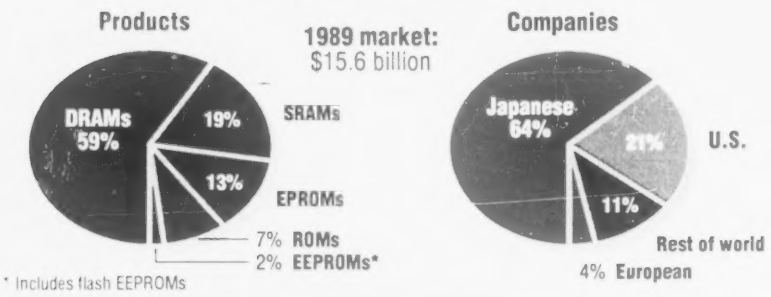
Anatoly Dverin

Semiconductor industry highlights

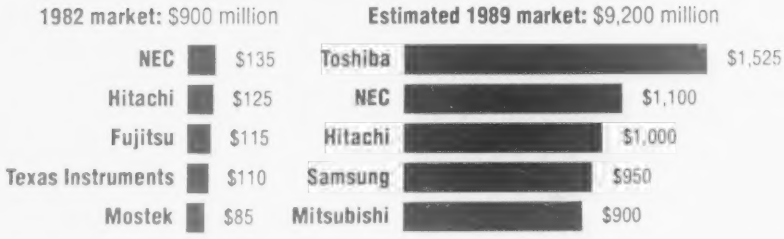
Worldwide merchant semiconductor markets



MOS memory market



DRAM market leaders ($ millions)



Source: Integrated Circuit Engineering Corp.

including automotive, consumer electronics and telecommunications, and seek out and team up with strong marketing allies.

Implementing those strategies, however, could be another story. One big reason is the notorious vagaries of the semiconductor market. Although DRAMs were a hot-ticket item in 1988 and 1989 — accounting for 19% of total IC sales, according to ICE — the market research company predicts DRAM sales will decline by 17% this year, to about $7.7 billion.

Observes Dataquest's Cox: "The problem with riding the DRAM crest is that you can go under when the market turns down." Citing the elasticity of 1-megabit DRAM prices (recently running between $7.50 and $8 in the United States), she adds that "companies with a large part of their portfolios devoted to those products are going to suffer."

Nevertheless, Samsung and Siemens appear committed to the DRAM market, at least for now. "The faster the microprocessors in PCs and workstations become, the more memory they need to be useable machines," reasons Samsung's MacDonald. "Laser printers are memory hogs, and HDTV will require an incredible amount of memory." He adds that while 64K, 256K and 1-megabit DRAMs accounted for most of Samsung's business in 1989, "4-megabit chips will be a major contributor this year."

Samsung: on the rise

Samsung has climbed through semiconductor company rankings with incredible speed, rising from $328 million in revenue in 1987 to $1.2 billion last year. World market share during that period rose from 0.9% to 2.3%, so how did Samsung do it?

"It's called investment," says MacDonald. "The more you invest, the faster you grow." Entering the merchant market in 1983, the company has invested about $1.2 billion during the past three years in its six fabrication facilities and two research and development centers in Korea, Japan and the United States.

At Siemens, meanwhile, Backes attributes the company's 1989 performance to substantial investments in two of its DRAM production facilities in West Germany and expanded assembly operations in Malaysia and Singapore. "Now we're reaping the harvest," he says. Markets of special interest to Siemens include chips for the automotive, telecommunications and industrial-control applications, especially in Western Europe.

Backes agrees with other observers that world DRAM demand is likely to remain flat for the short term. Looking further downstream, though, Siemens clearly intends to remain a major force in the market: Backes predicts that the company will capture 5% of the world market by the end of the decade — compared with 2.1% last year — largely via a joint R&D deal with IBM.

The Siemens-IBM arrangement — the first of its kind for either company — not only will slash development costs for each partner, but could also prove to be a powerful new Western competitor to Japan and Korea. "If they can pull it off, it's a good strategy to upset the balance of power in the DRAM world," says Jerry Worchel, a senior analyst at market research firm In-Stat Inc. □

U.S. firms get poor grades on design-for-testability

Every manager admits that easily testable products are a must in the global marketplace. So why are U.S. companies balking at designing for testability?

BY PETER BURROWS

Ken Parker, a manufacturing test manager at Hewlett-Packard Co.'s plant in Loveland, Colo., spotted an unsettling trend in mid-1988. Whenever HP's European customers came to look at board testers made at the facility, "We noticed that two people would come instead of one — not just a manufacturing manager, but a test manager as well. Sad to say, I saw more Europeans doing this than Americans."

Parker's concern is for the U.S. electronics industry's relative lack of interest in testability — an issue observers say is already a crucial element in any successful formula for global competitiveness. "Almost any garage can turn out an intensely complex product these days," Parker says, "and the only way to really succeed is to have good product testability."

The most fail-safe way to ensure testability is to make it a priority from the initial stages of research and development. This concept — known for more than a decade as "design-for-testability" (DFT) — is taking on added importance as rising product complexity pushes the cost of testing to exorbitant levels. Increased use of very large scale integration (VLSI) and surface mount technology has transformed products that were once easily testable into test engineers' nightmares. The result can be months of added testing or cost overruns that can wipe out the advantages of having a technologically unique product.

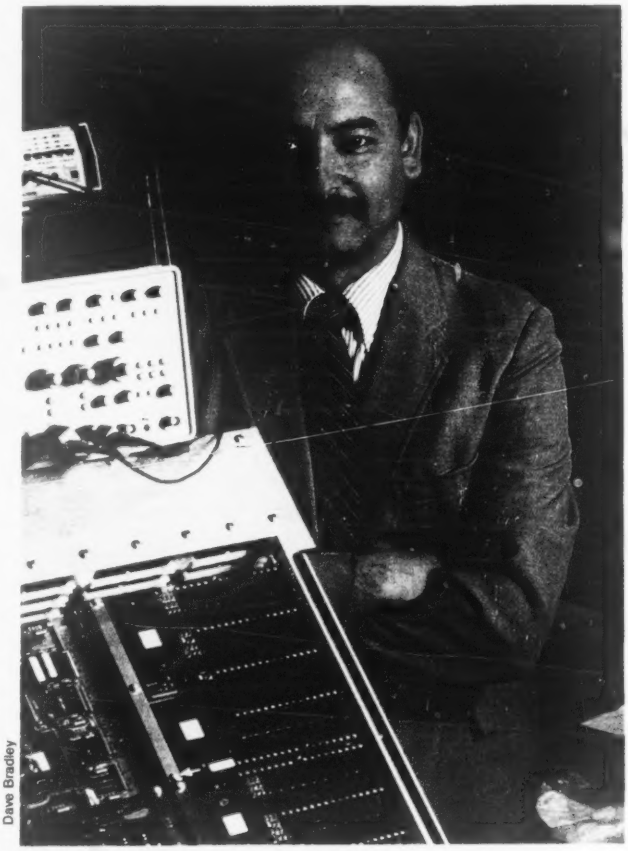
"Five years ago, testing typically took up 10% to 20% of total production cost," says consultant Jon Turino of Campbell, Calif.-based Logic Solutions Technology Inc. (LSTI). "Now, it's closer to 45%."

Given these spiraling costs, companies that can reduce their testing headaches by consistently generating easily testable product designs have a strategic advantage in the global marketplace. But testability tool vendors like HP's Parker say U.S. companies lag far behind their Asian and European competitors in implementing DFT.

Mike Carroll, vice president of marketing for CrossCheck Technology Inc. in San Jose, says the Japanese have shown the most interest in CrossCheck's promising built-in test technology. "American semiconductor companies come to us when their customers ask them to. The Japanese seem to understand the importance of testability right off the bat," he says.

Ironically, U.S. manufacturers know all too well the strategic benefits they are losing out on, according to a LSTI survey last year. Of the 58 technical professionals polled, 80% said design for testability was "very important." But in 70% of the companies, decisions affecting design testability were made by personnel with little training in testing issues, namely design engineers and project managers. "In only 20% of the organizations . . . do the test engineering people get to make decisions on whether or not optimum levels of testability get implemented," says Turino. The consultant adds that 55% of respondents doubted they could even round up all involved engineering managers for a meeting on the subject.

The fundamental barrier to DFT implementation in



Dave Bradley

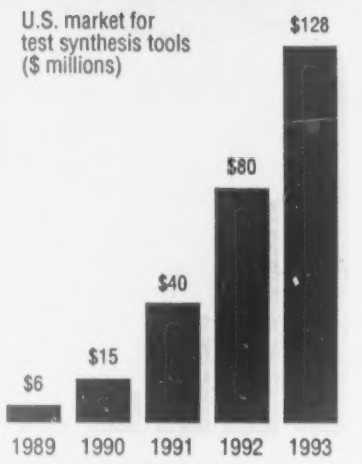
HP/Apollo's Bulent Dervisoglu understands design-for-testability phobia: "It's very difficult to quantify the benefits"

the United States, observers say, is a short-term profit strategy employed by many companies. "Managers rightly ask what the benefits of design-for-test actually are," says Bulent Dervisoglu, a consulting engineer at HP's Apollo Systems Division in Chelmsford, Mass. "It's very difficult to quantify the benefits of testability; it's far easier to quantify the costs."

The benefits of DFT, which include increased sales from improved time-to-market and reduced repair expenditures resulting from improved quality, rarely can be linked directly to DFT. But the up-front investment DFT requires is not hidden at all; initial expenses include the cost of additional computer-aided engineering software, higher-priced componentry with built-in test capabilities, as well as the time and money to train and acclimate personnel to new procedures. In the long run, reliability and timeliness more than compensate for these start-up costs, says Charles Foundyller, president of Daratrech Inc. of Cambridge, Mass. "But it is clearly a long-term payoff."

Process change can be the most traumatic prerequisite of all for DFT. Observers agree that U.S. firms must scrap the U.S. tradition of organizing product development along functional lines. Unlike the team-oriented approach in Japan, U.S. companies normally divide responsibility between design, manufacturing and test engineers. The typical end-result of the U.S. system is that an uninformed test engineer is saddled with an unfamiliar prototype with unrealistic instructions to test it thoroughly and get it out the door.

Test tools on the rise



Source: The Technology Research Group

The solution to this problem is clear, says Foundyller. "There has to be a member of the design team that worries about testability issues from the start." By moving testing upstream, companies can focus on process improvement rather than be doomed to a never-ending search-and-destroy campaign against poorly conceived designs. Instead of wasting resources on last-minute engineering changes, engineers can work together to eliminate test problems while they are still on paper.

The team approach also gives product development personnel a more market-driven view of their jobs. "That's probably where the Japanese have it over us," says Foundyller. "Their product teams are rewarded for building products to succeed long term on the market; our product teams are essentially just rewarded for getting it to market."

But breaking down the wall between design and test is not easy, as DFT does present designers with real problems. Rather than single-mindedly pursuing their traditional charter to maximize product performance, designers must donate time and budget to test-related problems. Some built-in, "ATE on a chip" technologies incur an even more direct cost; most of these require 10% to 20% of the area on a chip, and diminish speed by up to 20%.

Technology to the rescue

"What we really have to do is merge the design and test functions," says Victoria Hinder, research director at Boston-based The Technology Research Group. "What we need is test synthesis." In Hinder's view, components equipped with built-in test circuits and automatic test program generation (ATPG) software combine to automate test development. Test engineers, meanwhile, would evolve into little more than front-end consultants.

While true test synthesis is forecast to be years away, vendors have made great strides in closing the gap between design and test. CAE vendors, including Cadence Design Systems Inc., Mentor Graphics Corp., and TSSI Inc., and ATE vendors, such as GenRad Corp. and Teradyne Inc., are leading this technological charge. There are programs that ease the transfer and translation of data between designers and testers, programs that simulate environmental and functional testing on designs, and programs that automate aspects of design crucial to ensuring testability.

An often heard maxim among DFT experts is, "Don't be silicon wise and systems foolish." Their point: If testability is built into electronic components it will be much easier for

The many benefits of design-for-testability

- **Improved quality. Easily testable products will be tested more often and more thoroughly, ensuring reliability and customer satisfaction.**
- **Reduced capital investment. Components, boards and systems that are easy to test can often be tested on personal computers, workstations or low-cost test systems rather than million-dollar automatic test systems.**
- **Lower production costs. Up-front investments in design-for-testability quickly pay for themselves in reduced programming costs.**
- **Higher-performance products. Because of the quickening pace of product complexity, many products would be untestable without DFT.**
- **Faster time-to-market. Test development time can be drastically reduced, often by up to 30% or more, experts say.**
- **Improved profits. Although initially expensive, up-front investment in process improvement has less impact on profitability than does slow time-to-market.** □

manufacturers to test boards and systems. As a result, many semiconductor manufacturers and users are working to perfect various built-in test technologies.

More than 200 companies have participated in the collaborative Joint Test Action Group (JTAG), a project to develop a standard test bus and architecture for components equipped with boundary scan. This technology enables designers to link various elements of a chip through a network of test circuits that are easily accessed by test equipment.

CrossCheck licenses a technology to build test circuits directly into the substrate of gate arrays.

So far, most of the testability tools sold in the United States have been purchased by a handful of well-heeled industry leaders that have long-standing DFT programs. These include AT&T, HP, IBM and Texas Instruments Inc., as well as military contractors who must meet stringent testability specifications.

But others have been dissuaded by high initial costs and the trauma of change. "It's a real swamp once you get into it," says Dan Hutcheson, president of market researcher VLSI Technology Inc. "It deals with changes at almost every level, and it's very difficult for any one company to muster all those resources."

Hutcheson suggests that vendors of low-tech products with simpler design requirements can afford to forgo full-scale design-for-testability mania. But for companies in most fast-moving electronics markets, design-for-testability is becoming a necessity. "If you've got a product that no one has ever dreamed of, you can afford to be sloppy," says HP's Parker. "But without design-for-testability, you won't be successful for long." □

Apollo's long, hard road to testing efficiency

Bulent Dervisoglu's first contact with Apollo Computer Corp. was a one-on-one job interview in 1984 with then president and CEO Bill Poduska. Impressed with the applicant's credentials — he had a Ph.D. in design-for-test technology — Poduska promptly hired Dervisoglu and shuttled him through a series of top-level management meetings.

Dervisoglu emerged with a mandate to ensure that all component designs incorporated scan technology, in which microcircuits are designed into chips to link the elements of the chip to test points for easy interface with test equipment. Despite the strong support from the top, it still took Dervisoglu two years to overcome resistance to change in most other corners of the company.

Project managers recoiled at the prospect of investing time and money into a technology experiment that could not guarantee quantifiable benefits. Product designers, already under the gun to come up with viable, competitive products, claimed they had no time to worry about testing — that was the test engineer's job.

Dervisoglu decided his first task was to win over the product designers, since their jobs would be the first to be transformed by the requirements of the design-for-testability program. The scan technology chosen by upper management consumed 7% to 15% of the chip space the designers had to work with, and designers would be forced to engage in frequent and time-consuming discussions with engineers to ensure correct implementation.

Rather than simply appeal to the designers' loyalty to the company, Dervisoglu scoured the marketplace for software products that would make their jobs easier. He found many, including test-pattern generators that automatically produce many of the waveforms necessary to develop test programs and computer-aided engineering programs that do scan-related design with virtually no effort from designers.

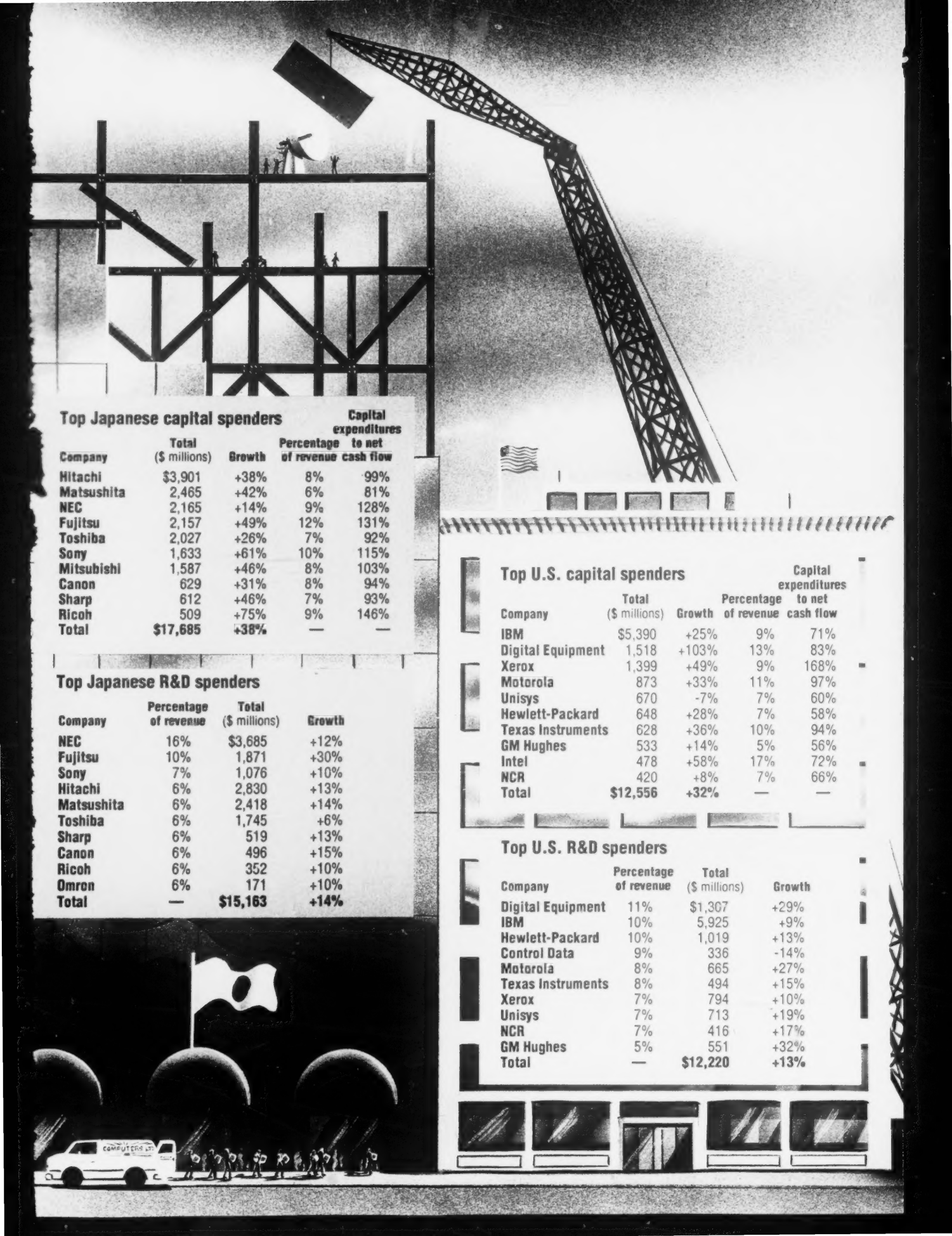
Once designers had signed on to the design-for-test program, Dervisoglu took aim at the project and manufacturing managers. "There are doubting Thomases in every group," says marketing manager Paul Bemis, "and, after all, these were the people who would have to build the thing. For them, it was a case of 'seeing is believing.'" Armed with testimonials from the designers and CAE vendors' projections of savings in time and money, Dervisoglu finally converted these naysayers as well, giving him the support he needed to make management's mandate a reality.

It took Dervisoglu two years to overcome resistance to change

Dervisoglu understands the widespread resistance. "Everyone has their own perspective and expertise, but that's no surprise," he reflects. "Their goals and the things that they think they are being measured on prevent them from focusing on the strategic benefits. Managers ask themselves, 'what if my designers can't handle it and I have to go back to the old way? All I've done is lose time, and my market share has been decreased.'"

Dervisoglu's efforts began to pay off in mid-1986, when the advanced technology division aggressively enforced "design for testability" in the development of the DN10,000 workstation, a 100 MIPS, quad-processor workstation so complex that test-program development would have been nearly impossible without the scan technology, says Bemis. Chip-level test times soon fell from about one man-year to about 20 hours. Board test, depending on the configuration, fell from multiple man-years to about a week. The company estimates that the program cut three months off total development time, a strategic advantage in a market where product lives are measured in months.

Impressive accomplishments notwithstanding, not all divisions of Apollo, now a division of Hewlett-Packard Co., have followed suit. Dervisoglu has made zealous supporters out of the advanced technology group that built the DN10,000, "But I cannot say that the entire company has been full-heartedly convinced." □



Top Japanese capital spenders

Company	Total ($ millions)	Growth	Percentage of revenue	Capital expenditures to net cash flow
Hitachi	$3,901	+38%	8%	99%
Matsushita	2,465	+42%	6%	81%
NEC	2,165	+14%	9%	128%
Fujitsu	2,157	+49%	12%	131%
Toshiba	2,027	+26%	7%	92%
Sony	1,633	+61%	10%	115%
Mitsubishi	1,587	+46%	8%	103%
Canon	629	+31%	8%	94%
Sharp	612	+46%	7%	93%
Ricoh	509	+75%	9%	146%
Total	**$17,685**	**+38%**	—	—

Top Japanese R&D spenders

Company	Percentage of revenue	Total ($ millions)	Growth
NEC	16%	$3,685	+12%
Fujitsu	10%	1,871	+30%
Sony	7%	1,076	+10%
Hitachi	6%	2,830	+13%
Matsushita	6%	2,418	+14%
Toshiba	6%	1,745	+6%
Sharp	6%	519	+13%
Canon	6%	496	+15%
Ricoh	6%	352	+10%
Omron	6%	171	+10%
Total	—	**$15,163**	**+14%**

Top U.S. capital spenders

Company	Total ($ millions)	Growth	Percentage of revenue	Capital expenditures to net cash flow
IBM	$5,390	+25%	9%	71%
Digital Equipment	1,518	+103%	13%	83%
Xerox	1,399	+49%	9%	168%
Motorola	873	+33%	11%	97%
Unisys	670	-7%	7%	60%
Hewlett-Packard	648	+28%	7%	58%
Texas Instruments	628	+36%	10%	94%
GM Hughes	533	+14%	5%	56%
Intel	478	+58%	17%	72%
NCR	420	+8%	7%	66%
Total	**$12,556**	**+32%**	—	—

Top U.S. R&D spenders

Company	Percentage of revenue	Total ($ millions)	Growth
Digital Equipment	11%	$1,307	+29%
IBM	10%	5,925	+9%
Hewlett-Packard	10%	1,019	+13%
Control Data	9%	336	-14%
Motorola	8%	665	+27%
Texas Instruments	8%	494	+15%
Xerox	7%	794	+10%
Unisys	7%	713	+19%
NCR	7%	416	+17%
GM Hughes	5%	551	+32%
Total	—	**$12,220**	**+13%**

Japan spends aggressively and builds for the future

How do the 10 leading electronics companies in Japan keep production costs heading down? By investing mightily in R&D and capital equipment

BY PAULA DOE

Japan's top 10 electronics corporations are investing nearly as much in research and development and capital equipment as do the top 100 U.S. electronics companies combined.

With this huge investment the Japanese companies are achieving 10% to 30% improvements in value added per worker in their main businesses in Japan. Manufacturing costs in Japan continue to decline in relative importance, as spending increasingly shifts upscale to such functions as research, design and marketing.

Few of Japan's leading electronics companies are spending more than a modest 6% to 7% of revenue on R&D, but such small percentages mean big money at these big companies. The top 10 Japanese companies alone, ranked by the R&D as percentage of revenue, spent $15.2 billion in 1988.

Other big Japanese companies spent billions more, although their R&D amounted to only 4% to 5% of revenue: Nippon Telegraph and Telephone Corp. (NTT) spent $1.67 billion; Mitsubishi Corp., $897 million, and Sanyo Electric Co. Ltd., $220 million. Adding just those companies to the top 10 brings the Japanese total to $18 billion, virtually matching the total R&D spending of all 100 of the biggest electronics R&D spenders in the United States combined, as tracked by ELECTRONIC BUSINESS.

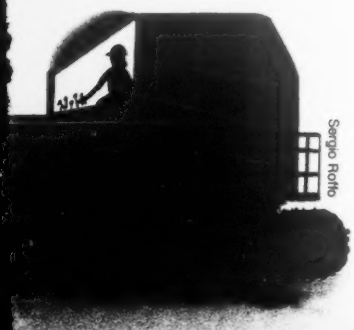
Five of the big Japanese companies and NTT each spent more on research than any U.S. electronics company, except IBM. NEC spent about two-thirds as much on R&D as IBM's $5.9 billion — although at $23 billion in revenue NEC is only about 40% the size of the U.S. giant. Even the second-tier Japanese manufacturers of consumer electronics and copiers, not usually regarded as technological powerhouses, each are investing $400 million to $500 million a year in research, more than all but a half dozen of the very largest U.S. electronics corporations.

Aggressive capital improvements

The leading Japanese electronics companies spent even more aggressively on capital improvements than they did on R&D. Total capital expenditures at the top 10 spending Japanese companies jumped 38%, to reach $17.7 billion. That nearly matches the $18.3 billion spent by the 100 top capital spenders in the U.S. electronics industry combined, according to ELECTRONIC BUSINESS. NTT spent another $13.4 billion in Japan on capital projects, as it continued to build its digital communications infrastructure.

While most of the big Japanese electronics companies invested nearly 100% or more of their net cash flow after dividends in capital expenditures, Ricoh Corp. invested 146% of its net cash flow in new plants in the United States, Europe and Japan. A common rule of thumb suggests investment of anything less than 100% of net cash flow compromises the capital base for short-term profit. The average for the 1988 ELEC-

Figures for fiscal year ending March 1989 for most companies
Conversion rate: ¥132 = $1
Source: Company reports



Sergio Roffo

TRONIC BUSINESS 200 was 84%.

All this big spending is possible because of Japan's low cost of capital. The typical Japanese electronics company can afford to put 14% or more of its revenue into R&D and new plant and equipment, despite operating earnings of only 6% or less of revenue, because it can get an ample supply of capital at an effective interest rate of return of only 3%.

The most notable effect of this aggressive investment at the parent companies in Japan is sharply increased value added. Cost structure is shifting, too, as companies spend less and less on the physical work of manufacturing and sharply more on the brain work of research and design, and planning and marketing.

Value added jumped an average of 20% at the leading electronics companies in Japan, with increases ranging from 10% at Hitachi Ltd. to more than 30% at Sony Corp.

Productivity, as measured by value added per employee soared at similar rates, as the companies held employment in Japan relatively steady. These figures are for the parent company, so they reflect only the output of the parent's main plants in Japan, increasingly concentrating on the company's most technologically advanced products.

But capital isn't being used nearly as efficiently as workers. With the big influx of capital investment, value added per dollar invested dropped

Productivity and cost structures of leading Japanese companies

	Fujitsu	Change	Hitachi	Change	Matsushita	Change	NEC	Change
Fiscal 1989 sales ($ billions)	**$15.2**	**+16.9%**	**$24.5**	**+10.4%**	**$30.9**	**+24.3%**	**$19.3**	**+10.3%**
Productivity								
Estimated value added from operations (as percentage of total sales)								
Operating income	5.7%	+68.0%	5.2%	+33.2%	3.5%	+84.4%	4.8%	+41.4%
Expenses other than outside purchases:								
Personnel expense	10.5%	+3.7%	15.4%	+4.3%	7.0%	+11.6%	9.7%	+4.6%
Rents & leases	—	—	0.3%	+16.9%	—	—	1.4%	+11.4%
License fees	—	—	—	—	—	—	—	—
Taxes (charged as operating expenses)	0.8%	+44.7%	0.9%	+33.1%	0.9%	+22.0%	0.7%	+22.7%
Depreciation	5.8%	+16.4%	3.9%	+4.7%	1.4%	+16.4%	3.6%	+4.1%
Total value added from operations	**22.8%**	**+17.8%**	**25.7%**	**+10.2%**	**12.8%**	**+26.5%**	**20.2%**	**+12.6%**
Value added/employee	$67,900	+17.2%	$82,400	+9.8%	$95,300	+21.3%	$103,400	+13.4%
Value added/dollar personnel expense	2.17	+13.6%	1.68	+6.0%	1.84	+13.6%	2.09	+7.7%
Value added/dollar investment	0.30	+4.6%	0.42	-5.3%	0.24	+5.6%	0.28	-4.8%
Relative costs								
(as percentage of total sales)								
Cost of goods sold	**61.4%**	**+12.8%**	**75.7%**	**+9.1%**	**81.1%**	**+24.6%**	**67.9%**	**+8.3%**
Cost of manufacturing	52.4%	+9.5%	75.2%	+8.3%	21.9%	+9.7%	55.1%	+9.0%
Materials	41.0%	+8.7%	42.1%	+11.4%	16.6%	+7.9%	45.1%	+6.8%
Labor	6.9%	+3.5%	13.2%	+3.8%	3.3%	+6.1%	6.8%	+1.4%
Overhead	5.2%	+10.9%	20.1%	+8.1%	2.6%	+10.1%	18.2%	+12.9%
Inventory adjustments and transfers between accounts	-0.7%	—	-0.2%	—	-0.6%	—	-15.0%	—
Selling, general, and administrative costs	**32.9%**	**+18.7%**	**19.1%**	**+12.0%**	**15.4%**	**+14.8%**	**27.2%**	**+11.0%**
Personnel	3.5%	-6.0%	2.2%	+7.6%	3.6%	+17.1%	2.9%	+13.2%
Advertising and promotion	1.0%	+38.0%	1.0%	+32.5%	1.1%	+36.0%	1.2%	+9.1%
Operating income	**5.7%**	**+68.0%**	**5.2%**	**+33.2%**	**3.5%**	**+84.4%**	**4.8%**	**+41.4%**
Personnel expense/employee*	$31,300	-2.5%	$49,200	-1.6%	$52,000	+1.4%	$49,600	+0.2%
Mfg. labor costs/SG&A personnel costs	1.97	-0.2%	6.00	-3.0%	0.92	-10.0%	2.34	-12.0%

* Change in personnel expense per employee is figured in dollars
Percentages do not add up to 100% because of rounding
Conversion rate: ¥132 =$1
Percentage change in yen, March 1988 to March 1989

Figures are for the parent company only (unconsolidated)
Figures are for fiscal year ending March 1989 for most companies

Source: Japanese language reports published by Japan's Ministry of Finance

about 5% at Hitachi and NEC, while it rose 4% to 5% at Sony, Fujitsu Ltd. and Matsushita Electric Industrial Co. Ltd. Toshiba Corp. received the most return for its money, in part because it invested less aggressively than most of the other companies. It saw a 14% increase in value added per dollar invested, to 50 cents to the dollar.

Selling, general and administrative costs climbed sharply faster than manufacturing costs at the major Japanese computer and chip makers — NEC, Fujitsu and Hitachi — where those nonmanufacturing costs already take up 20 cents to 30 cents of every revenue dollar. At Fujitsu, for example, SG&A costs jumped 19%, while manufacturing costs increased only 10% to support 17% growth in sales.

Sony		Toshiba	
	Change		Change
$9.50	**+22.2%**	**$22.10**	**+8.9%**
3.9%	+202.0%	6.0%	+121.0%
8.7%	+7.9%	14.3%	+9.6%
—	—	0.6%	+353.0%
—	--	0.6%	+3.9%
—	—	—	—
3.2%	+24.6%	5.0%	+2.7%
15.8%	**+32.4%**	**26.5%**	**+21.3%**
$93,500	+30.3%	$85,100	+23.2%
1.82	+28.5%	1.86	+10.7%
0.17	+3.6%	0.50	+13.5%
80.4%	**+20.2%**	**72.8%**	**+5.2%**
83.7%	+25.4%	54.6%	+10.3%
77.2%	+27.3%	36.2%	+10.6%
6.4%	+6.6%	10.8%	+7.9%
5.9%	+16.3%	7.8%	+8.5%
-5.8%	—	-0.2%	—
15.7%	**+15.1%**	**21.1%**	**+6.8%**
2.3%	+11.7%	3.5%	+3.4%
1.5%	+11.4%	0.9%	+19.5%
3.9%	**+202.0%**	**6.0%**	**+121.0%**
$51,500	+6.2%	$45,800	+5.5%
2.78	+4.0%	3.09	-7.0%

Nonmanufacturing spending

All the major electronics producers stepped up their spending on marketing, paced by increases of 30% or more at Fujitsu, Hitachi and Matsushita. On advertising and promotion, Matsushita spent $329 million, Hitachi $253 million, NEC $228 million, Toshiba $196 million, Fujitsu $154 million and Sony $143 million.

Spending on manufacturing labor relative to spending on SG&A personnel decreased at all of the top Japanese companies, the ratio of manufacturing to SG&A personnel costs declining less than 1% at Fujitsu to 12% at NEC. The cost of manufacturing labor edged up 1% to 8% at most of the companies, while spending on support personnel jumped 8% to 17%. Fujitsu and Toshiba were the exceptions, with their manufacturing labor costs rising faster than those for support personnel. Fujitsu, however, actually managed to cut its SG&A personnel costs by 6%.

Personnel expenses in general were the area in which the top Japanese electronics producers most successfully held the line on cost increases. Already a pricey $30,000 to $50,000 per employee, dollar denominated personnel costs remained about the same as the previous year. Manufacturing labor costs increased very little despite sharply higher sales. But direct labor costs, at a scant 3% to 13% of revenue, are already a small portion of total costs. □

In compiling our exclusive annual analysis of Japanese spending, ELECTRONIC BUSINESS *sifts through reams of detail from Japanese corporate reports (Yuka Shoken Hokoku) from the Ministry of Finance. These Japanese materials contain a wealth of information not available in English language annual reports. The figures can also be found in various Japanese-language corporate directories, such as the annual Kaisha Nenkan published by Nihon Keizai Shimbun Inc.*

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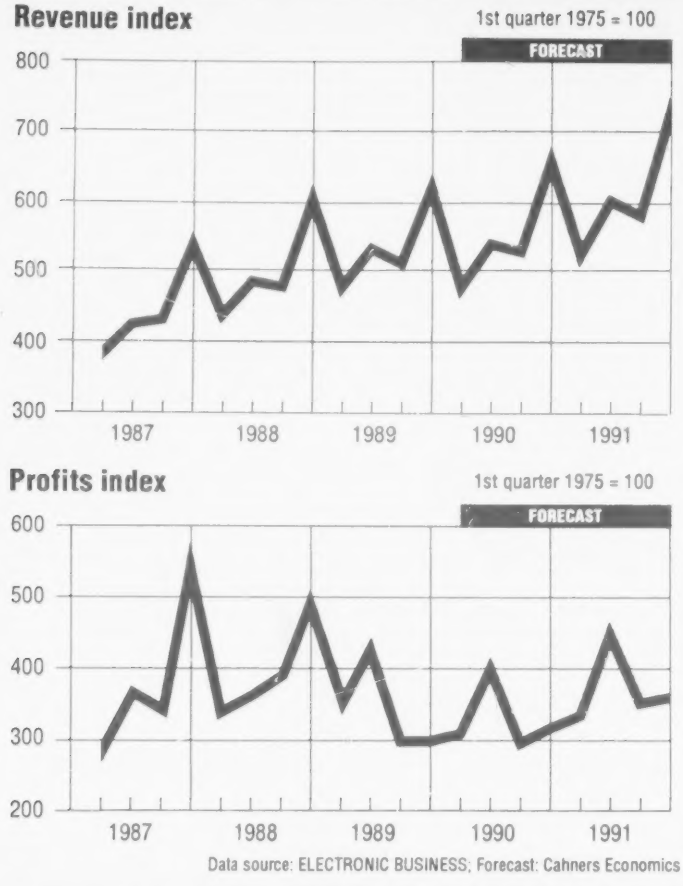
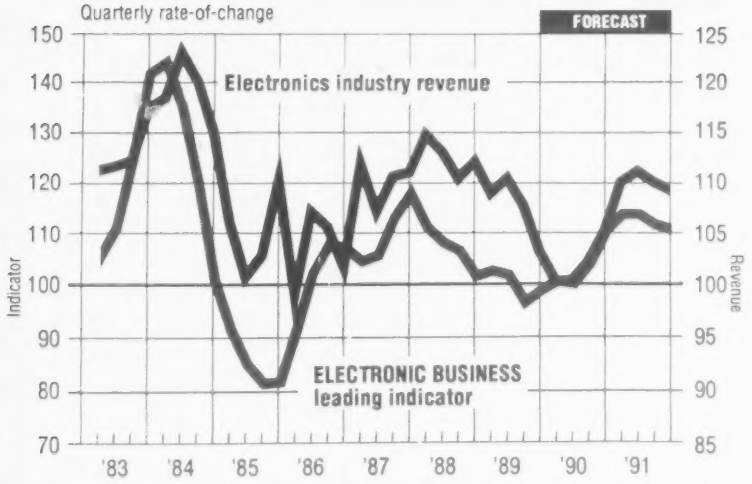
ELECTRONIC BUSINESS indexes



Data source: ELECTRONIC BUSINESS; Forecast: Cahners Economics

Leading indicator vs. electronics industry revenue



Data source: ELECTRONIC BUSINESS; Forecast: Cahners Economics

Riding the electronics profits roller coaster

The roller-coaster ride for electronics profits continues unabated. Taking a turn for the worse in the final quarter of 1989, the ELECTRONIC BUSINESS profit index plummeted nearly 40% from the year-ago level. By nature, however, profits have always been a wild beast.

Profits, as measured by a representative sample of 16 electronics companies, hit a record-breaking 544 (index: 1975 QI = 100) in the final quarter of 1985, and plunged to 256 exactly a year later. The profits index set a new record at 545 in the last three months of 1987, held relatively steady at 492 in 1989, and has just taken the plunge to 297 this past winter.

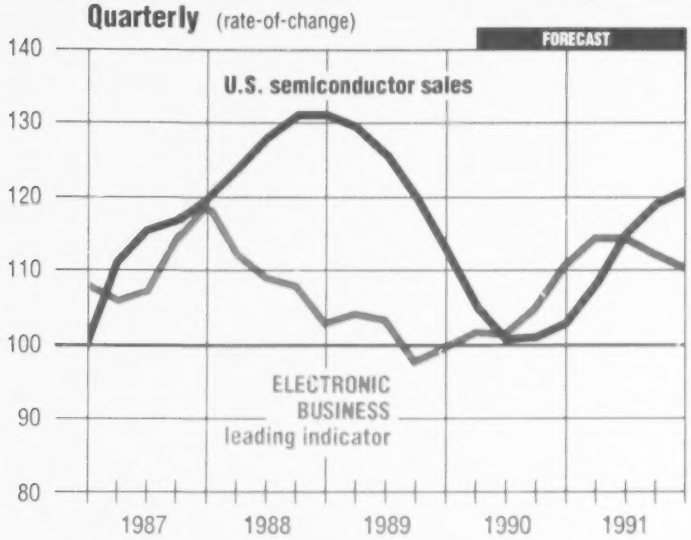
Ten of the 16 companies measured saw profits fall at the end of 1989. IBM contributed the most to the aggregate decline just because of the sheer volume of its profits. While most computer companies remained profitable, this group of 16 generally has seen the largest declines from year-ago profit levels. Excluding IBM, the ELECTRONIC BUSINESS profit index would have risen 16% in 1989. With IBM, the composite profit index fell 14%.

Only one electronics company stood in the red in the final quarter of last year. Six of the 16 companies — Advanced Micro Devices, E-Systems, Harris, Honeywell, Intel and Motorola — actually saw profits rise from year-ago levels.

Will the profits bath last? Much of the decline can be attributed to nonrecurring events. With the underlying economy weakening for electronics manufacturers, year-end 1989 marked an opportunity to restructure and control expenses. While most electronics companies will continue to face sluggish demand in 1990, further profit losses should be moderated by the decisive economic actions of the past year. Still, Cahners Economics predicts profits will linger around 1989 levels. Profits are forecast to fall another 4% in 1990, before surging back upward with the stronger economy in 1991.

ELIZABETH B. BAATZ, Cahners Economics

ELECTRONIC BUSINESS leading indicator



The ELECTRONIC BUSINESS leading indicator will most likely hang around the 100 to 101 level for the first half of 1990, indicating the shallow nature of the current electronic industry business cycle slowdown. In January, the indicator inched-up to 102.6 from a revised 102.4 at the end of 1989. Stronger-than expected semiconductor stock prices and contracts and orders for new plant and equipment contributed to this increase.

Source: Cahners Economics

SPECIAL OFFER: A detailed 12-page background paper is available on the ELECTRONIC BUSINESS leading indicator. To obtain your complimentary copy, please contact Elizabeth Baatz at Cahners Publishing Co., 275 Washington St., Newton, Mass., 02158-1630 USA, telephone (617) 558-4368, fax (617) 558-4402

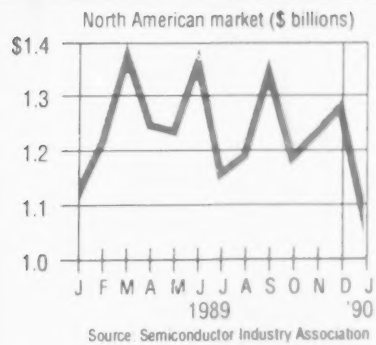
Electronics industry indicators this month

	Latest month	Previous month	Year ago	1989 average
ELECTRONIC BUSINESS leading indicator (rate-of-change, Jan.)	102.6	102.4	103.3	100.9
U.S. semiconductor bookings ($ millions, 3-month average, Jan.)	$1,214	$1,221	$1,193	$1,204
Weekly hours of semiconductor production workers (monthly average, Dec.)	41.7	41.1	40.9	40.1
Electronic components leadtime index (1977 = 100, Feb.)	94.6	75.8	104.0	102.5
S&P's semiconductor stock price index (1970 =10, monthly average, Jan.)	60.5	57.9	49.0	55.7
Change in electronic components inventories ($ millions, SA, Dec.)	-$86	+$27	-$135	-$4.4
Contracts and orders for plant and equipment ($ billions, SA, Dec.)	$50.5	$43.0	$43.7	$43.5

SA = seasonally adjusted, all other data is not seasonally adjusted

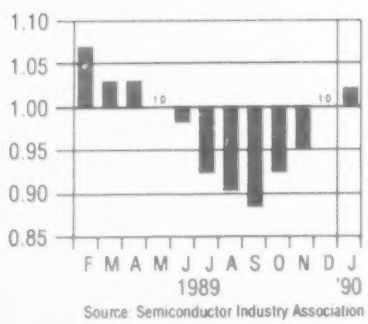
Sources: Semiconductor Industry Association, U.S. Bureau of Labor Statistics, *Electronics Purchasing* magazine, Standard & Poor's, U.S. Commerce Department, U.S. Bureau of Economic Analysis

Semiconductor sales



Source: Semiconductor Industry Association

Semiconductor book-to-bill ratio



Source: Semiconductor Industry Association

Component inventory-to-shipments

Source: U.S. Commerce Department